Impact of Social Dominance on Stress Vulnerability in Rats

A THESIS TO BE SUBMITTED TO

THE UNIVERSITY OF TRANS-DISCIPLINARY HEALTH SCIENCES AND TECHNOLOGY

FOR THE AWARD OF THE DEGREE OF

DOCTOR OF PHILOSOPHY

BY

DURGA JEYALAKSHMI SRINIVASAN

UNDER THE GUIDANCE OF

PROF. SUMANTRA CHATTARJI

NATIONAL CENTRE FOR BIOLOGICAL SCIENCES (NCBS)
BANGALORE, INDIA

SEPTEMBER 2024

Synopsis

Stressful events are linked to psychiatric disorders such as depression, anxiety, and PTSD, affecting behavior, cognition, and social interactions. Research indicates significant variability in how individuals cope with stress, influenced by genetic, epigenetic, early life experiences, and social status. Social hierarchies play a crucial role in the lives of social animals, offering various advantages such as access to resources and mating opportunities. Although individual differences in vulnerability to stress are increasingly recognized, the influence of social hierarchy on vulnerability remains relatively understudied.

Therefore, this thesis investigates how the hierarchical status of an animal (i.e., dominant vs. subordinate) influences its response to stress. Male Sprague-Dawley rats were used as a model system, and their dominance status was determined using the social dominance tube test. Detailed information about the experiments is provided in the second chapter of this thesis.

Previous studies in rodents suggest that while chronic stress models are common, even a single acute stress event can produce lasting effects, including changes in morphological plasticity across various brain regions and increased anxiety-like behavior. Chapter 3 of this thesis discusses the impact of acute stress on the established hierarchy among rats living together in a cage. We observed that the pre-determined hierarchical rank among rats housed in the same cage was relatively unaffected by stress, except in measures of the time taken to complete the test.

Next, in Chapter 4, we investigated whether the familiarity of the opponent's status affects the winning probabilities of stressed rats. Surprisingly, stress had differing effects on hierarchy formation. Higher-ranked animals exhibited resilience to stress, whereas lower-ranked animals displayed enhanced submissiveness. Given the importance of understanding how an animal's internal state influences its behavior during social conflicts, we performed a detailed analysis of inter-animal behavior during competitions. We observed that stressed dominant rats employed a more effortful strategy, characterized

by increased pushing and resistance, while stressed subordinates tended to retreat during most conflicts. We also analyzed the influence of stress and dominance on structural plasticity at the level of dendritic spines in the basolateral amygdala and medial prefrontal cortex, given their pivotal roles in stress response and dominance behaviors. Interestingly, we found that poorer behavioral resilience caused by a combination of stress and lower social status was associated with increased dendritic spine density in the amygdala—a brain area that encodes emotional experiences—but no difference in dendritic spine density among the test groups in the medial prefrontal cortex.

In Chapter 5, we investigated the impact of social rank on stress-induced social anxiety, particularly concerning juvenile stimuli. Our findings revealed a differential effect of stress on sociability. We observed that higher-ranked rats subjected to stress exhibited reduced sociability with juvenile rats, whereas lower-ranked rats subjected to stress exhibited a similar sociability profile to unstressed high and low-ranked rats.

Chapter 6 discusses the impact of chronic immobilization stress on the established hierarchy within a cage. Surprisingly, we observed similar results to those seen with acute stress. The pre-established hierarchy among rats in a cage remained unchanged even after exposure to chronic stress. Subordinate rats, whether stressed or not, tended to withdraw from conflicts when faced with dominant rats they were familiar with. This result once again highlighted that the dominance hierarchy is highly stable in a known group once established and that neither acute nor chronic stress affects their dominance status.

Overall, this thesis explores the interplay between stress and social dominance behavior in rats. We confirmed that dominance status is a key variable influencing differential susceptibility to stressful exposure. Our findings suggest that considering one’s social standing is essential when addressing stress-related psychiatric disorders.